AN ECOLOGICAL SURVEY OF THE DEVIL'S GARDEN RESEARCH NATURAL AREA MODOC NATIONAL FOREST, CALIFORNIA

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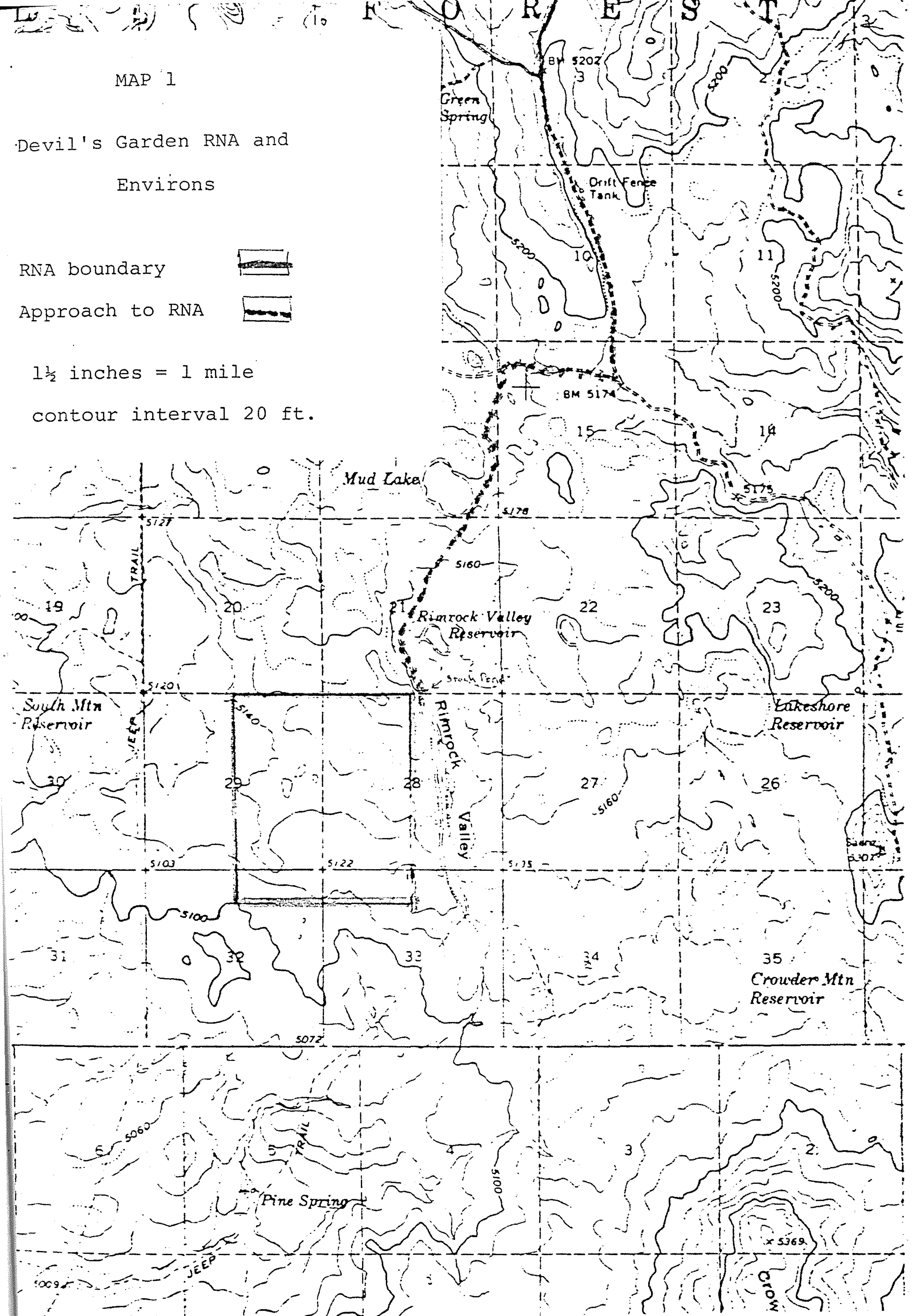
INTRODUCTION

The Devil's Garden Research Natural Area encompasses 800 acres of Western Juniper woodland and sagebrush shrub-steppe vegetation on the Modoc Plateau of northeastern California. The area is of low relief with elevations ranging from ca. 5100 ft. to 5190 ft. Access to the area is from the east via Hwy. 299 at Davis Creek. After turning west on the West Side Road one travels across the causeway over the southwest corner of Goose Lake and up the west shore of the lake for ca. 10 miles before turning west again and rising up onto the Devils Garden Plateau. At this point it is about 8 miles to a fork labled"Pine Spr, Crowder Mtn."After a left it is ca. 5.5 miles to the stock pond just east of the NE boundary of the RNA (see Map 1).

History of the RNA:

The Devil's Garden RNA was formally proposed as a natural area in 1931 and was established in February 1933, thus being the second RNA established in California. The reasons for setting aside the then 1600 acre area centered on the area's large, relatively undisturbed expanse of Western Juniper woodland and its potential future economic importance as pencil stock, posts, and cordwood (this apparently warranted study). No ecological study of any kind was made of the area prior to establishment.

In 1963 the original 1600 acre reserve was reduced to ½ its size by an order from the Chief Forester after recommendations from the Regional Forester and the Director of PSW. The reasons for this drastic reduction were cited as following the regulations in FSM 2725.4. Apparently it was thought that ½ of the original area


MAP 1
Devil's Garden RNA and
Environs
RNA boundary
Approach to RNA
1½ inches = 1 mile
contour interval 20 ft.
F O R E S T
Green Spring
BM 5202
Drift Fence Tank
BM 5174
Mud Lake
Rimrock Valley Reservoir
Stock Pond
Rimrock Valley
South Mtn Reservoir
Lakeshore Reservoir
Crowder Mtn Reservoir
Pine Spring
TRAIL
JEEP
5200
5160
5140
5100
5060
5127
5120
5103
5122
5135
5072
5175
5178
x 5369
Crow

was too disturbed by grazing or woodcutting to warrant natural area status, although again no ecological study of the area was undertaken to assess the actual extent of the damage.

In 1969 Clark Gleason visited the area and filed an IBP natural area check sheet. This was the first time a partial list of plants and a classification of plant communities were made. Other features of the area including the patterned ground, a few notable animal species, and the research significance associated with the 1959 burn within the area were mentioned. Gleason commented on the still-noticeable influence of cattle and horse grazing within the RNA. He expressed concern about the close proximity of a salt-lick and stock pond to the NE corner of the RNA and recommended that the area be fenced to exclude domestic livestock. The bulldozed fire trails at the 1959 burn were also mentioned by Gleason as not compatible with RNA status. He suggested that future fires in the area should be fought by aircraft and hand methods.

In 1971 Dan Cheatham (then Research Forester) visited the area and filed a report with PSW. He noted that although still nothing had been done about the grazing, the only notable influence was in the extreme NE corner of the RNA adjacent to the stock pond. Cheatham suggested, and apparently the local Modoc NF officials concurred, that by moving the salt block and watering facility to another location the cattle would be dispersed from the natural area.

In 1975 an inventory of the natural landmarks of the Great Basin was compiled (Bostick et al 1975). This report was critical of the grazing practices allowed in the RNA by Modoc NF(although it mistakingly presumed that the aforementioned stock pond was actually

located within the RNA). The authors were also critical of the use of bulldozers to help contain the 1959 fire and suggested that this may have irreparably damaged the RNA. The authors comment that given its history of boundary revision, the next reduction may exclude the bulldozed area and that eventually the RNA "may well run out of acres." Dan Cheatham in a 1975 letter to PSW also suggested that the 1963 reduction was unreasonable and a better solution may have been to move the road crossing the southern portion of the old RNA and halt grazing and woodcutting from the affected areas.

SIGNIFICANT FEATURES OF DEVIL'S GARDEN RNA

Western Juniper (_Juniperus occidentalis_ subsp. _occidentalis_):

The juniper woodland at Devil's Garden is representative of a fairly widespread xeric vegetation type ranging from SE Washington, SW Idaho, south through E Oregon, NW Nevada to W Siskiyou, NE Shasta, and much of Lassen and Modoc Counties, California (Vasek and Thorne 1977). This Western Juniper woodland is the northwestern representation of the Great Basin pinyon-juniper zone and is the most xeric of the tree-dominated zones in the Pacific Northwest. It is primarily a savanna region ecotonal between Ponderosa Pine forest and sagebrush shrub-steppe (Franklin and Dyrness 1973).

Unlike its southern relative, _J. o. australis_ (mountain juniper) of the California mountains, Western Juniper does not typically attain great girth or age. The largest trees on the RNA are between 1.2 and 1.5 m dbh, ca 10 m tall, and not more than ca 500 years old.

The Western Juniper woodland is presently only represented in two RNAs; Devils Garden, and Horse Ridge (in Central Oregon). Horse Ridge is similar to Devil's Garden climatically (Franklin and Dyrness 1973), however the dominant soil group differs by being deeper and

more porous, containing much pumice, and the shrub and herb composition is somewhat different as a result (Driscoll 1964). The Devil's Garden RNA apparently occurs within the largest existing stand of *J. o. occidentalis*, covering much of the Modoc Plateau (Kuchler 1977). According to Vasek and Thorne (1977) the density and size of junipers increases on the Modoc Plateau with the gradual elevation rise to the northeast until an ecotone with Ponderosa Pine forest is reached at the highest levels of the plateau. Thus, the Devil's Garden RNA is near the local optimum development of this vegetation type, situated as it is only ca. two miles south and 100 ft. below the local beginnings of Ponderosa Pine forest. The density and stature of the Modoc juniper woodland is clearly reduced at lower elevations to the south (e.g. along Hwy. 299 west of Alturas) where it gives way to *Artemisia* shrub steppe.

Artemisia shrub-steppe:

This is the vegetation characteristic of much of the Great Basin Province of the Intermountain West. At Devil's Garden this vegetation type forms a mosaic with juniper woodland on less rocky, more poorly drained soils. The Modoc Plateau carries the largest expanse of *Artemisia* communities in California (Young et al 1977). The *Artemisia* and Juniper communities at Devil's Garden hold equal importance for study as this is the only RNA in California set aside within either of these two major vegetation zones.

High Plant Diversity in a Stressful Environment:

Unlike much of the region dominated by Western Juniper and *Artemisia*, Devil's Garden has an exceptional diversity of herbs and subshrubs. This is doubtless reflective of the relatively lightly grazed and otherwise undisturbed nature of the RNA, but

may also reflect other more long-term environmental influences peculiar to the Modoc area.

Although I only conducted a limited amount of vegetation sampling, my impression from walking over almost the entire RNA is that herb and subshrub diversity is very high and also very constant throughout the upland juniper and Artemisia associations. It is very unusual for 40 to 50 species of plants to be found on any given 1000 m^2 of xeric habitat (or any habitat for that matter) in California. The fact that this many species are more or less uniformly distributed over a very uniform habitat is exceptional. The local diversity of perennial herbs , grasses, and subshrubs is particularly striking and invites questions about the origins and maintenance of this diversity.

In general, an extremely stressful environment with cold winters, hot summers, and low precipitation such as occurs on the Modoc Plateau would not be expected to support a high diversity of species. In keeping with the stability-time hypothesis (Colinvaux 1973) it is unlikely that a high diversity of plants would develop in a stressful environment unless they had been in existence for a long time. Although most of the species in question are perennials, which can avoid stress by going dormant (thus allowing an equilibrium population of adapted species to be maintained despite environmental stress), it is questionable that there has been sufficient time allotted for the adaptation of such a large number of species to a single environment. Apparently the Great Basin desert flora did not exist before the mid Pliocene (Axelrod 1977), and this is a substantially shorter length of time than has been allotted for the development of other diverse, but stressful environments (e.g. the Sonoran Desert,Axelrod 1977).

Local diversity is, however, not the same as regional diversity. The overall floristic diversity of the Modoc Plateau is certainly much lower than many other areas in California (Stebbins and Major 1965). The low diversity of many other areas of Artemisia and Western Juniper communities has been documented by Driscoll (1964), Dealy (1971), Franklin and Dyrness (1973), Young et al (1977) and others. As far as I have been able to determine no more than 25 species have been listed for any single community. Thus, in the RNA it is typical for a given small area to contain as many as twice the maximum number of species listed anywhere else in similar communities. This fact certainly warrants study. Perhaps the local high diversity has to do with specific local soil and drainage characteristics (see Young and Evans 1970). However, this apparent discrepancy may also be due to differing sampling techniques, etc. Regardless of the reasons for the differences in diversity between this and other juniper-Artemisia areas, an adequate explanation for the high within-habitat diversity at Devil's Garden should be sought out.

Succession on the 1959 burn:

In the summer of 1959 a lightening-caused fire engulfed ca. 150 acres of open juniper woodland and upland Artemisia vegetation on the southeastern portion of the RNA. Little is known about succession in Western Juniper woodland (Franklin and Dyrness 1973), though a fair amount is known about natural and grazing-mediated succession in Artemisia communities (see Young et al 1977). The 1959 fire provides a way to study the successional trends on the little-known juniper woodland. Several surprising points have already emerged from a brief vegetational survey of the burn undertaken in this report (see vegetation section). These include a higher than expected

density of young saplings of *Juniperus* and shrubs of *Artemisia tridentata* and *Purshia tridentata*, species thought to be very susceptible to eradication by burning. In addition, the seral community (Gleason 1969) dominated by non-native herbs such as *Verbascum* and *Cirsium* seems to have all but vanished only 20 years after the burn.

Patterned Ground:

Throughout much of the RNA and adjacent areas low 30 to 50 ft. diameter circular frost mounds dot the ground (Fig. 1). Locally these mounds may be as much as three feet high and occur in dense aggregations. Frost "lines" of rocks also occur locally within the RNA. Both of these landforms are usually associated with periglacial activity (Malde 1964). However, the continental ice sheet did not come closer than ca. 400 miles from Devil's Garden. Very similar mounds and lines have been noted from the W. Snake River Plain in Idaho (Malde 1964) and from several parts of Siskiyou County, California (Masson 1949). Elsewhere in California patterned ground is closely associated with high montane environments (e.g. the High Sierra, *fide* Scott Stine, UCB Geography Dept.). These mounds at Devil's Garden and other parts of NE California are the lowest elevation examples of such landforms in California. The cold, dry, relatively continental climate of the area and the predominant heavy clay soil subject to much expansion and contraction during freezing and thawing may be responsible for their presence.

There is still some uncertainty as to whether the local examples of patterned ground are relicts of the last ice age or whether they are still being actively maintained at present. This could possibly be clarified through research conducted in and adjacent to the RNA.

Figure 1. Circular frost mound ca. 200 m east of NE corner of RNA. Note absence of rocks on mound and surrounding base and denser growth of Artemisia arbuscula on mound. Height above surrounding flat ca. 2½ ft., diameter of structure ca. 35 ft.

CLIMATE

The climate of the Devil's Garden RNA is harsh by California standards. Estimates of the amount of average annual precipitation range from 250-380 mm (in original establishment report) to ca. 380-500 mm (Kahrl 1979). Unlike many areas in California precipitation in the Devil's Garden area is more or less evenly distributed between the months of October through June and shows no pronounced peak in January-February. At this elevation ppt. is largely in the form of snow, though there is generally no long term accumulation. The snow that does fall tends to be blown into shallow drifts in the lee of rocks, trees, etc. The lack of a widespread snow cover in the winter is evidenced by the *Letharia* lichen growth on the junipers down to the base of their trunks. Mean January temperature minima are between -9 and -11^{o}C (Franklin and Dyrness 1973) which is as low as temperatures throughout much of the northern Great Basin.

Summers are hot and dry (July mean maxima ca. 30^{o}C). However, even the driest months , from July through September, have trace amounts of rain (Kahrl 1979, data from Alturas), unlike many parts of central and southern California.

GEOLOGY AND SOILS

The Devil's Garden is a part of the Modoc Plateau, a region of block faulted, basalt covered basins and ranges in NE California and adjacent Oregon. The Modoc Plateau is geologically part of a much larger region (often called the Columbia Plateau) extending from NC Washington to NE California, including most of Oregon east of the Cascades. This entire area is covered by

basalt lava flows erupted primarily during the Miocene ca. 15 to 25 million years ago.

The cause of all of these extensive flood basalts appears to have stemmed from a change in the subduction of the earth's crust along the early Miocene Pacific coast of NW North America. According to Alt and Hyndman (1978) a large slab of Pacific Plate seafloor sliding under the North American Plate may have broken off and sunk rapidly, causing the rocks underlying E. Washington, E. Oregon, and NE California to slide westward to fill in the void behind the sinking piece of sea floor. This westward movement of the crust created weak North-south trending fissure zones through which basalt magma was able to seep up from the partially molten sub-crustal rocks. The general cessation of volcanic activity east of the Cascades at the end of the Miocene may have marked the beginning of a new continuous slab of seafloor descending under Western North America, which slowed the westward movement of rock beneath Oregon and rekindled the Cascade volcanos (Alt and Hyndman 1978).

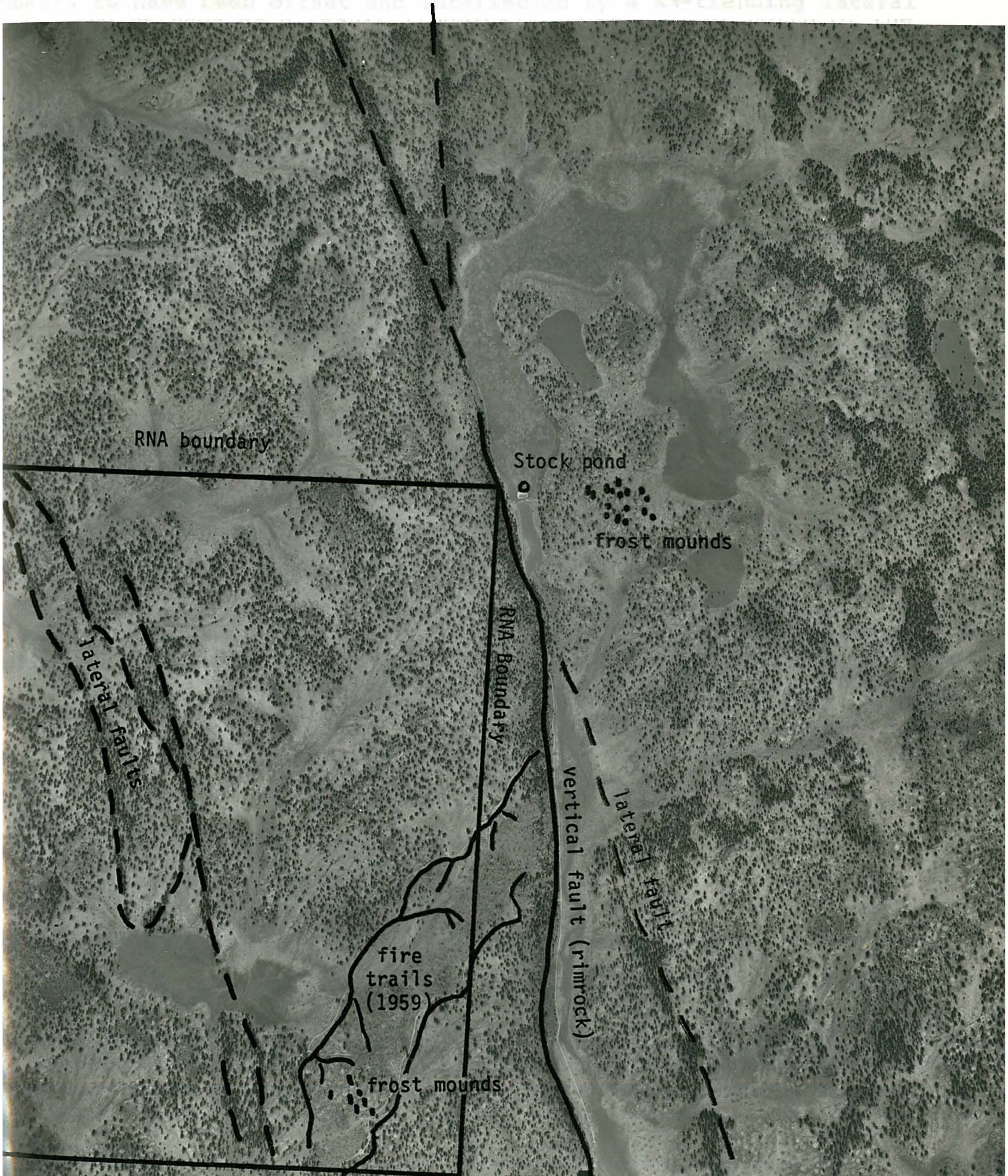
The block faulting characteristic of SE Oregon, NE California, and much of the Great Basin began ca. 10-15 million years ago and still continues today. South of the Brothers Fault Zone in East-central Oregon the lava plateau is now broken into a landscape of mountains and valleys separated by abrupt fault escarpments. The pattern of faulting indicates that NW California and W Oregon are moving north relative to the eastern sections of these states. The distribution of this north-south displacement (estimated by Alt and Hyndman to be ca. 50 miles) is spread over many faults, unlike the few faults in Central California that bear the brunt of this movement. Most of the faults either trend nearly northwest or

slightly east of North. Both sets of faults appear to be moving simultaneously. All the northwest trending faults have right-lateral movement, while the north trending ones are vertical with one side rising into a ridge or mountain bordering on a depression or valley.

Volcanic activity associated with this faulting, though not as widespread as the Miocene eruptions, has continued through the Pliocene and Pleistocene up to recent times and resultant basaltic and rhyolitic flows cover much of this area. The local Devil's Garden Basalt is one of the largest of these post-Miocene flows. Although often lumped with many other similar flows in NE California and called "Warner Basalt", there is considerable evidence that the Devil's Garden Basalt is a distinct entity (MacDonald 1966).

The Devil's Garden Basalt is actually the largest continuous exposure of basalt in NE California and covers ca. 700 square miles. The basalt slopes gently to the southwest from a maximum elevation of ca. 6000 ft. near the Oregon border to ca. 4500 ft. south of Clear Lake Reservoir, though its point(s) of origin is (are) unclear. The average thickness of this basalt is ca. 100 ft., but may range up to 360 ft. The age of the basalt has not been accurately determined. Warner Basalt in the generic sense, probably ranges from Miocene to Pleistocene. However, the best estimate for the age of Devil's Garden Basalt is between late Pliocene and early Pleistocene (MacDonald 1966).

The faulting within the RNA is certainly not on as grand a scale as in many parts of the Modoc Plateau, yet a dominant series of northwest-trending faults clearly show in aerial photos of the area (Figure 2). These lateral traces are actually much less noticable from the ground except for the denser juniper woodland associated with their rockier and deeper soil. The only vertical


RNA boundary
Stock pond
frost mounds
lateral faults
RNA Boundary
vertical fault (rimrock)
lateral fault
fire
trails
(1959)
frost mounds

fault partially within the RNA is that which forms the western side of Rimrock Valley. This is a northward-trending scarp averaging 15-20 ft. high. The section of the scarp actually within the RNA appears to have been offset and intersected by a NW-trending lateral fault, and perhaps as a result it quickly looses height north of the NE corner of the RNA (see Figure 2).

The basalt of the RNA is generally a weathered gray-brown and not blackish as is typical of recent basalt flows. The rocks are not strongly vesicular and may be massive as along part of the Rimrock Valley fault scarp. Only along the rimrock fault and in a few areas near the southern RNA boundary are there any large unbroken outcrops of basalt. The typical form of this rock in the RNA is in fragments of from a few inches to two feet across separated by expanses of chestnut-brown clay soil. As a result of alluvial deposition, there are usually fewer surface rocks in the shallow basins.

Soils:

The soils of the RNA may be divided into three major types. Those developing on the slightly elevated areas dominated by *Juniperus* , those of the shrub and herb dominated uplands, and those of the closed basins.

The soils underlying the largest area of the RNA can be classified as haplargids (see Franklin and Dyrness 1973). These are soils with pedogenic horizons low in organic matter which are never moist for longer than three consecutive months. They have a horizon in which loamy clay has accumulated and may or may not have some alkali. These are the areas dominated by juniper and also include the soils filling the cracks in the rimrock area along the NE corner of the RNA.

The soils underlying the gently sloping *Artemisia arbuscula*

association of the uplands can be classified as haploxerolls. At their best development they are soils with a nearly black, friable organic-rich surface horizon that are high in bases. These soils are typically dry for a long period during the summer. Haploxerolls have a subsurface horizon high in bases, but with less accumulation of clay than haplargids.

In at least one basin in the RNA surface water accumulates for enough time in the spring to have the soil be characterized as a vertisol. The soil in this flat is clayey with wide, deep cracks forming during the dry period after the spring snow melt.

The clayey soil that forms from the decomposition of the Devil's Garden Basalt is important in the local development of the circular patterned ground. A detailed description of the formation of similar mounds in parts of Siskiyou County has been published (Masson 1949). According to this account the doming occurs where there are local concentrations of clay in the soil, for example between outcrops of weathered basalt. Since clay holds more water than other soils, when it is saturated and frozen it will expand in relation to the surrounding soil of lower clay content. Adjacent clay patches in the soil touch during expansion and adhere upon thawing and drying. Thus, by repeated expansion and contraction a clay patch may grow until a large, slightly domed concentration of clay-rich soil is formed. The widespread stone pavement and the stone circles around the bases of some mounds also are a result of freezing and thawing. The rocks and stones in the portion of soil subject to freezing are first concentrated at the surface because the surface freezes first and expands pulling rocks up with it. Rings are formed after rocks are pulled up to the surface of a dome and then pushed out by clay expansion and forced down to the

base of the dome by gravity. The maximum size of the domes is apparently controlled by the amount of clay concentrated in the surrounding soil. Ultimately a stage is reached when a mound is surrounded by an area of clay-free soil too wide to allow capture of additional clay from the outside.

At Devil's Garden the patterned ground appears to occur most regularly on the gently sloping shallow, rocky soil of the Western Juniper woodland. It does not regularly occur in the basins where the soil is a more uniform clay. It may occur in areas with extremely high concentrations of rocks and small boulders, attesting to the physical power of this phenomenon.

Given the sharply defined outlines of many of the frost mounds, it seems likely that current climatic conditions are sufficient to maintain these structures at Devil's Garden. The lack of any continuous insulating snow cover during the cold winter months would tend to expose the soil to deep enough freezing to continue the processes of upfreezing and radial movement of stones, and expansion of the clay pockets.

VEGETATION

Young and Evans (1970) provide a diagrammatic breakdown of how the physical and biotic environments mesh to form communities on the Modoc Plateau. They suggest that on disjunct basalt ridges with heavy clay soils *Juniperus occidentalis* will form a woodland with *Artemisia arbuscula* in the understory, while on and adjacent to basalt rimrock with heavy clay soils *J. occidentalis* forms a woodland with *Artemisia tridentata*. Young and Evans describe an *A. arbuscula* community from areas of fractured basalt scablands and also from

flats with heavy clay soils. In seasonally inundated basins they show a very scant cover of plants growing on vertisols. These physical environments are all represented on the RNA and to a fair degree agree with the scenario proposed by Young and Evans. However, since these authors' descriptions are brief and in some cases differ from the situation at Devil's Garden, I will define the local plant associations somewhat differently. There are two major formations on the RNA; a juniper woodland and an Artemisia shrub-steppe. These can be broken down into several associations. For an estimate of the acreage and location of vegetation see map 2.

Rimrock Juniper Association:

This is the vegetation type that is most heavily dominated by trees and large shrubs in the RNA. It occurs only on the extreme NE corner of the area and covers no more than ca. 10 acres (Figure 3). The vegetation is generally dominated by Juniperus although Cercocarpus ledifolius and Prunus virginiana var. melanocarpa may be locally dominant. Several herbs, grasses and shrubs are more or less restricted to the sloping, relatively deep soils and rock outcrops of the rimrock area. Besides Cercocarpus and Prunus these include:

Artemisia tridentata

Amalanchier pallida

Chrysothamnus viscidiflorus

C. nauseosus subsp. albicaulis

Cirsium utahense

Elymus triticoides

Ribes cereum

Sambucus caerulea

Scrophularia lanceolata

Verbascum thapsus

Several annual grasses such as Bromus tectorum, B. brizaeformis, and B. japonicum are more densely aggregated in this association than in any other, largely because of the shaded microhabitat provided by the denser growth of juniper (Young and Evans 1973). Two 10 X 10 m plots were sampled in the rimrock association of

MAP 2

VEGETATION OF DEVIL'S GARDEN RNA

scale; ca. 4 in. = 1 mile

	acreage
open juniper woodland	505
successional juniper woodland	80
upland *Artemisia arbuscula*	160
rocky *A. arbuscula* subtype	5
closed basin *A. arbuscula*	43
rimrock juniper	7
total	800

MAP 2

VEGETATION OF DEVIL'S GARDEN RNA

scale; ca. 4 in. = 1 mile

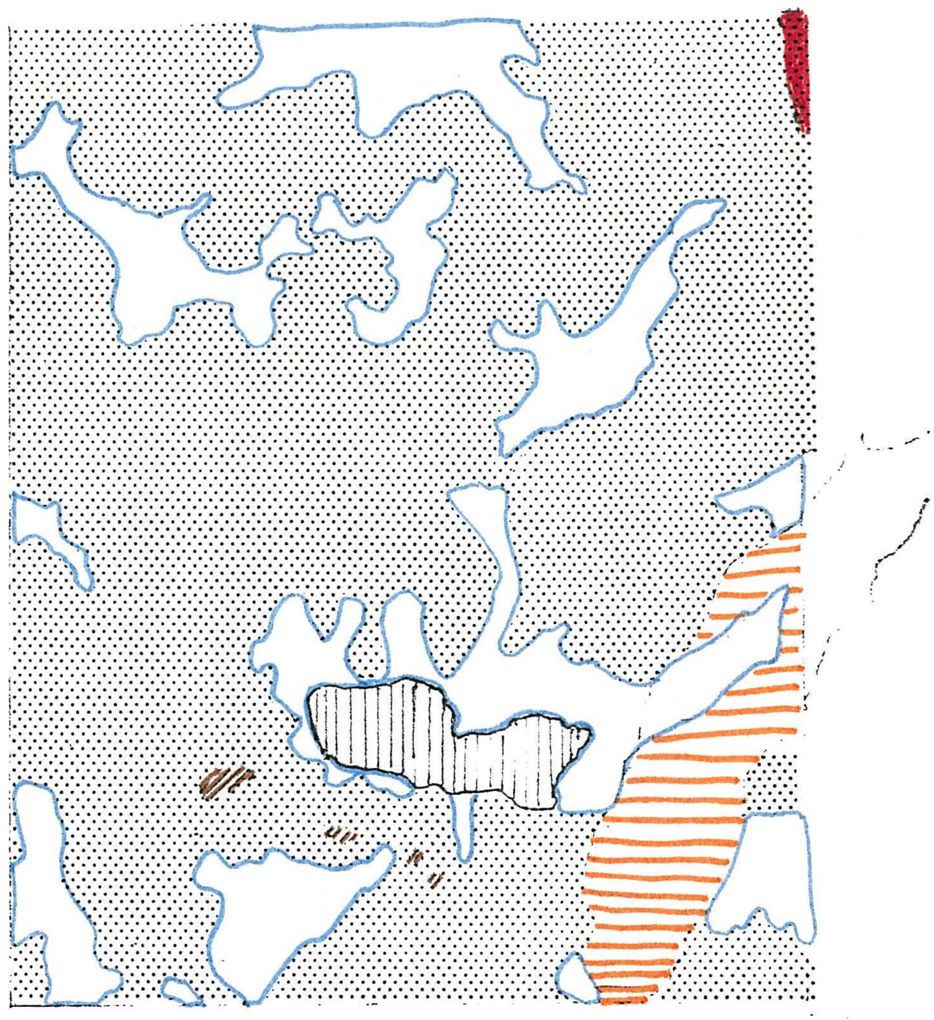


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Figure 3. Rimrock association on NE corner of RNA. Artemisia tridentata, Chrysothamnus viscidiflorus, and Prunus virginiana subsp. melanocarpa are prominent plants in foreground. Note guano deposits and associated orange lichen from Bushy-tailed Woodrat perches in rocks.

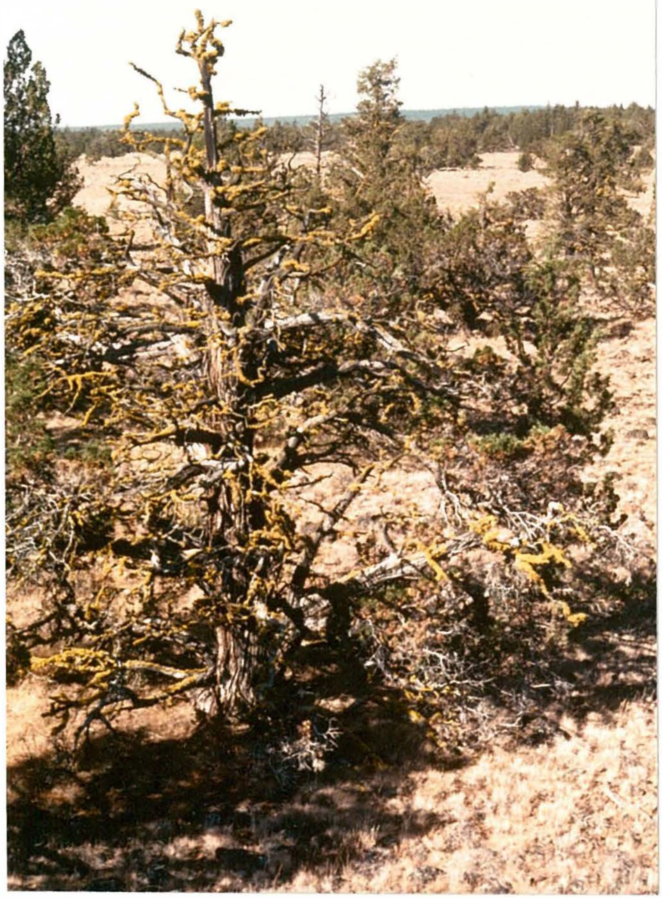

Figure 4. Typical open juniper woodland in NE section of the RNA.

the RNA. The capsulized results are shown in Table 1.

Unlike the situation documented by Burkhardt and Tisdale (1969) no large new waves of juniper colonization appear to be advancing at the base of the rimrock. Several age classes are represented throughout the association although the most common trees are clearly of intermittent age (ca. 30 cm dbh).

The depth of the soil in the rimrock cracks and the channelling effect these cracks have on runoff from the surrounding rocks undoubtedly are strong influences on the relatively high density of trees and arborescent shrubs in this association.

The rimrock area is also more heavily used by vertebrates than any other association in the RNA. Particularly conspicuous are the many large woodrat houses and guano deposits on the rocks (see Fig. 3) left by <u>Neotoma</u> <u>cinerea</u> (Bushy-tailed Woodrats). Bird densities are generally much higher than in the surrounding flats and open woodlands. Reletively higher productivity (seeds, fruits, insects, etc.) and the protective cover of the denser vegetation and the outcrops, themselves are probably largely responsible for the high animal density.

This association compares most closely to the "rimrock type" described by Young and Evans (1970) and does not apparently have a close counterpart in Oregon (Franklin and Dyrness 1973). Although the rimrock community described by Burkhardt and Tisdale (1969) for SW Idaho shares similar physiognomy, it has a much lower diversity of understory shrubs and herbs, and occurs on rhyolite which weathers to a sandy, not clayey soil.

Open Juniper Woodland:

This association is the most extensive and species-rich in

Table 1: Vegetation sampling on two 10 X 10 m plots in the rimrock association.

	Plot #1		Plot #2	
Trees:	density	basal area (cm^2)	density	basal area (cm^2)
J. occidentalis	2	305	4	1357
C. ledifolius	2	84	3	731
P. virginiana	1	5	0	0
J. occidentalis (seedlings)	1		3	
Shrubs:				
A. tridentata	2		3	
Chry. nauseosus	7		7	
Chry. viscidiflorus	6		2	
Purshia tridentata	0		1	
Prunus virginiana	4		1	
Ribes velutinum	1		6	
Ribes cereum	3		1	
Sambucus caerulea	0		1	
Herbs & Grasses present:				
Scrophularia	X			
Elymus triticoides	X			
Bromus tectorum	X		X	
B. japonicus	X		X	
B. briziaeformis	X			
Penstemon deustus	X			
Sitanion hystrix	X		X	
Agropyron spicatum	X		X	
Calochortus macrocarpus	X		X	
Carex douglasii			X	

the RNA and covers ca 75% of the area. Comparable vegetation types occur on the lava plains of Oregon and depending on the density of junipers, have been alternately assigned to juniper woodland communities or *Artemisia* shrub-steppe with juniper as a subdominant (Franklin and Dyrness p. 247). In many areas of the RNA northern juniper woodland does grade gradually into upland *Artemisia* shrub-steppe. In general, the dominant understory plants are similar between these two associations and thus it seems wise, for the sake of vegetation mapping, to include all areas with some juniper cover as part of the open juniper woodland.

As was mentioned previously, in contrast to the climax Northern juniper woodlands described elsewhere (Driscoll 1964, Burkhardt and Tisdale 1969, Thorne and Vasek 1977) the diversity of herbs, subshrubs, and perennial grasses in the understory is extremely high at Devil's Garden. Most of these species are shared with adjacent upland *Artemisia arbuscula* shrub-steppe; however, several characteristic species appear to only grow in the shade and duff accumulation areas of junipers. The high litter, reduced exposure microhabitats beneath junipers have been mentioned by others (e.g. Eckhert in Franklin and Dyrness 1973) as housing specific associations of plants. At Devil's Garden the species characteristic of this microhabitat include: *Senecio integerrimus*, *Fritillaria pudica*, *Hackelia cusickii*, *Lithophragma tennellum*, *Plectritis macrocera* var. *grayii*, and *Collinsia parviflora*. Additional species especially common in these situations include the three annual *Bromus* species, *Stipa columbiana* (?), *Ribes velutinum*, *Allium acuminatum*, and *Arabis sparsflora*.

The openings between junipers house a similar association to the upland *A. arbuscula* shrub-steppe. However, the openings typical

of the juniper woodland are on a rockier substrate with many boulders (up to 60% of surface) and tend to carry a higher density of certain herbs and grasses than the more open treeless flats. Among the species most characteristic of the juniper openings are:

Agropyron spicatum	_Erigeron elegantulus_
Artemisia arbuscula	_Eriogonum douglasii_
Arenaria aculeata	_Eriogonum umbellatum_
Arabis holboelii var. _retrofracta_	_Microseris lacinata_
Cordylanthus ramosus	_Penstemon laetus_
Crepis modocensis	_Thelypodium flexuosum_

For a representative view of open juniper woodland at Devil's Garden see Figure 4.

Two 50 X 20 m plots were sampled within this association. Table 2 summarizes the results.

Successional Open Juniper Woodland:

This sub-type of the previous vegetation type occupies the 1959 burn and covers ca. 80 acres in the RNA (Figure 5). Although at this time it is not dominated by _Juniperus_, the number of charred stumps and snags suggest a similar past density to adjacent undisturbed open woodland.

The present composition of the burn vegetation differs from the surrounding woodland in ways other than by simply the reduction of junipers. Several shrubs that are particularly uncommon in undisturbed open woodland are more common here. These include: the two rabbitbushes; _Chrysothamnus nauseosus_ var. _albicaulis_ and _C. viscidiflorus_; Bitterbrush (_Purshia tridentata_), Service-berry (_Amelanchier pallida_) and Big Sagebrush (_Artemisia tridentata_). In addition, _A. arbuscula_ is more common than in most other upland

Figure 5. A portion of the 1959 burn looking south. Note large <u>Chrysothamnus nauseosus</u> in foreground next to charred stump, also note the survivor trees rear left and center.

Table 2: Vegetation sampling on two 50 X 20 m plots in the open Western Juniper woodland.

	Plot #1 density	Plot #1 cover (cm^2)	Plot #1 $\bar{x}$ dbh (cm)	Plot #2 density	Plot #2 cover (cm^2)	Plot #2 $\bar{x}$ dbh (cm)
Trees:						
J. occidentalis	34	34,944	33.8	20	39,560	37.4
seedlings:						
J. occidentalis	1			5		

	Plot #1	Plot #2
Grasses (presence):		
Festuca idahoensis	x	
Agropyron spicatum	x	x
Bromus brizaeformis	x	
B. japonicum	x	x
B. tectorum	x	x
Koleria cristata	x	x
Poa brachyglossa	x	x
P. fibrata (?)	x	
Sitanion hystrix	x	x
Stipa columbiana (?)	x	x
S. thurberiana	x	x
Shrubs:		
Artemisia arbuscula	x	x
Ribes velutinum	x	x
Eriogonum umbellatum	x	x
Herbs:		
Lomatium nudicaule	x	x
Penstemon deustus	x	
P. laetus	x	x
Gayophytum sp.	x	
Epilobium panicual tum	x	x
Eriophyllum lanatum	x	x
Hackelia cusickii	x	x
Draba verna	x	x
Collinsia parviflora	x	x
Phlox douglasii	x	x
Arenaria aculeata	x	
Arabis holboelii	x	
Lomatium vaginatum (?)	x	
Antennaria luzuloides	x	x
Lomatium leptocarpum	x	x
Arabis sparsiflora	x	x
Trifolium gymnocarpon	x	
Crepis modocensis	x	x
Erigeron elegantulus	x	
E. chrysopsidis	x	
Dodecatheon conjugens	x	x
Senecio integerrimus	x	x
Balsamorhiza hookeri	x	x
Idahoa scapigera	x	x

Table 2 (continued):

Herbs (continued):	Plot #1	Plot #2
Plectritis macrocera	x	x
Haplopappus stenophyllus	x	x
Allium acuminatum		x
Microseris lacinata		x
Arenaria congesta		x
Thelypodium flexuosum		x
Antennaria dimorpha		x
Cordylanthus ramosus		x
Polymonium micrantha		x
Saxifraga fragosa		x
Calochortus macrocarpus		x
Hemizonia lobbii (?)		x
Gilia lepetala or tenerrima		x
Erigeron linearis		x
Penstemon spectabilis		x

areas. Several herbaceous species appear to be locally restricted to the burn and include: Geum ciliatum, Cirsium vulgare, Achillea millefolium, Crepis acuminata, Phacelia imbricata, Madia citriodora, and Arenaria nuttallii subsp. fragilis.

The regeneration of juniper is better on the burn than on the average plot of undisturbed open woodland. On a 50 X 20 m plot seven juniper saplings (under 2 m) and one seedling were counted. The presence of several mature Juniperus individuals still living within the general area burned undoubtedly aided in recolonization. On this same plot there were 15 charred juniper stumps. The dominant understory plants were A. arbuscula (ca 75 individuals) and the grass Sitanion hystrix. Other important plants included Purshia tridentata (9 individuals), Eriogonum umbellatum (6 individuals) E. douglasii (5 indivs.), Eriophyllum lanatum, Arenaria nuttallii var. fragilis, Senecio integerrimus, Bromus tectorum, B. brizaeformis, Arabis sparsiflora, A. holboelii subsp. retrofracta, Lomatium vaginatum, L. nudicaule, Gayophytum sp. Poa juncifolia, Epilobium paniculatum, and Hemizonia lobbii.

It appears that the lower diversity of understory plants is a fairly uniform feature of the burned area. The grass diversity is substantially lower than in adjacent undisturbed woodland with the only common species being Sitanion and Bromus tectorum.

The reason for the abundance of such shrubs as Purshia, Chrysothamnus, and Artemisia and the Juniperus saplings is unclear. Although it is tempting to assume that their increase is due to the fire, other evidence suggests that although Chrysothamnus (especially viscidiflorus) may increase after fire (Young and Evans 1974), Purshia and A. tridentata are known to decrease (Young et al 1977). Another confounding problem is that the terrane in the

fire-damaged area is somewhat steeper than much of the surrounding woodland and may have originally held an association similar to the rimrock association (which does carry all of these species). This question could possibly be tested by measuring soil depth and composition under the burn and in adjacent juniper woodland. *Purshia* (particularly) is known to do best on deep, well-drained soils (Young et al 1977). Thus, perhaps the presence of *Purshia* and the other shrubs on the burn has more to do with the characteristics of the original substrate than the after-effects of the burn.

One undeniable effect of the burn was the extensive growth of weedy-herbaceous species which sprang up after the blaze. This seral association was apparently dominated by the non-native *Verbascum thapsus* and *Cirsium vulgare* (Gleason 1969) and apparently persisted for at least 10 years. Today, however, native vegetation dominates the burn. *C. vulgare* was represented by only one individual within the RNA and *V. thapsus* was locally extinct when I visited the burn in August 1983. However, the bulldozed trails are still noticeable and are largely uncolonized. The slow recovery of these trails doubtless has much to do with loss of permeability of the surface soil due to compaction, and the continual use of some of these trails by livestock.

Upland *Artemisia arbuscula* Shrub-steppe:

This association is the second largest in the RNA, covering about 200 acres. *A. arbuscula* is the dominant shrub (or more properly, subshrub), but often not the dominant plant. In absolute cover and density the dominants are usually perennial grasses including; *Festuca idahoensis*, *Koeleria cristata*, *Poa juncifolia*, *Stipa columbiana* (?), *Danthonia unispicata*, and *Sitanion hystrix*. In many parts of

this association herb and subshrub diversity is as high as in adjacent juniper woodland, but it is reduced in lower, poorly drained areas and also in extremely rocky areas.

The upland _A. arbuscula_ association generally occurs on very gentle slopes (< 5%) or shallow drainage channels. Both of these environments may be briefly flooded in the spring, but are better drained than the _A. arbuscula- Chrysothamnus viscidifolius_ subsp. _parvulus_ association of the low basins. This association is thus midway on the continuum between the open Northern Juniper woodland of the upland portions of the RNA and the aformentioned _A. arbuscula-_ _C. v._ subsp. _parvulus_ association lying in the lowest basin in the RNA.

Dealy (1971) divides the _A. arbuscula_ dominated vegetation of the Silver Lake Mule Deer Range (ca. 80 miles N of Devil's Garden) into three "ecosystems". However, he states that all three may occur on a single given "scab flat". The differences between them are influenced by edaphic characteristics including depth of the A horizon, depth to restrictive layer (clay pan or rock), texture of B horizon (loamy or clayey), stoniness of soil, and overall drainage. These same principal variables are doubtless important in the Devil's Garden RNA, on a large scale influencing the differences between the several main juniper and _Artemisia_ associations as well as on a smaller scale in this single association. Although I did not quantify the differences in the _A. arbuscula_ upland there is clearly a cline in vegetation between the rockier upland segments and the more clay-rich lowland drainage areas in this association.

On a typical drainage channel leading into the basin in the S-central portion of the RNA the following species were most common:

Artemisia arbuscula	_Perideridia bolanderi_
Sitanion hystrix	_Polygonum esotericum_

Lomatium nudicaule

Poa brachyglossa (juncifolia)

Danthonia unispicata

Arenaria congesta

Eriophyllum lanatum

Bromus tectorum

Lomatium leptocarpum

Navarretia minima

Balsamorhiza hookeri

Trifolium gymnocarpon

Bromus japonicum

Epilobium paniculatum

Gayophytum sp.

It is clear by the presence of such species as Polygonum, Navarretia, Perideridia, and others that this zone is more heavily influenced by seasonal flooding than more upland shrub-steppe. I would guess that the soil in such areas must remain moist for at least two months during the growing season for such an assemblage of species to exist. The soil of this subtype may be rocky (ca. 30% surface rock average), but also has some larger clay openings which usually exhibit some cracking upon drying.

The upland subtype of the A. arbuscula shrub-steppe is physiognomically very similar to adjacent openings in Northern Juniper woodland, but does appear to be the local center of distribution for several species. Although dominants such as Koeleria cristata, Festuca idahoensis, Stipa columbiana (?), and A. arbuscula, as well as many of the less common herbs, are shared with juniper openings (see Appendix 1), the following core of species are most characteristic of this subtype:

Penstemon speciosus

Lomatium triternatum

Zigadenus paniculatus

Hemizonia lobbii (?)

Poa fibrata

Phlox douglasii subsp. rigida

Antennaria luzuloides

Plagiobothrys cusickii

Gilia lepetala

Erigeron linearis

A third subtype of this association occurs on the extremely rocky scablands such as just south of the basin in the South-central portion of the RNA. These are patches where weathering of the original lava flow surface has not progressed as rapidly as on the surrounding flats, and many large unbroken chunks of basalt cover the ground. *A. arbuscula* is relatively uncommon here, but is still the dominant shrub. Other subshrubs include *Eriogonum umbellatum* and *E. douglasii*. The most important single species over many of these areas is the perennial herb *Arenaria congesta*. *Arabis holboelii* subsp. *retrofracta*, *Festuca idahoensis*, and *Sitanion* hystrix are occasional. There are very few other species.

Closed Basin *Artemisia arbuscula*-*Chrysothamnus viscidiflorus* subsp. *pumilus* Association:

This vegetation type covers ca. 65 acres of the basin in the South-central portion of the RNA. The basin is characterized by a summer-dry, deeply cracked, clayey vertisol. The overall dominant of this association is *A. arbuscula*. Unlike the previous association, *A. arbuscula* is much more important than the perennial grasses and also tends to be larger. The subdominant species is the small yellow-green shrub *Chrysothamnus viscidiflorus* subsp. *pumilis*. Species diversity of the annually flooded basin vegetation is fairly low. Other important plants are *Lomatium leptocarpum*, *Polygonum esotericum*, *P. douglasii*, *Gayophytum* sp., *Poa juncifolia*, *Hemizonia lobbii* (?), and *Perideridia bolanderi*. Parts of this basin are almost devoid of vegetation except for a low density of annuals such as *Polygonum* and *Gayophytum*.

As with the upland *A. arbuscula* association, there is a cline in the development of this vegetation type depending on the duration

of annual flooding. The shallow basin in the RNA probably is flooded with several inches of water for at least a month in most years. After the surface water evaporates, the soil must remain moist for another two months or so. Areas in Rimrock Valley, just east of the RNA show the effects of a longer wet period with *Artemisia cana* forming a ring around hydrophillic vegetation dominated by *Juncus* sp., *Carex douglasii*, and vernal pool species such as *Psilocarpus* sp., *Eryngium* sp., *Navarretia* sp. and *Downingia* sp.

CURRENT GRAZING PRESSURE IN THE RNA

In August 1983 most of the RNA appeared to have suffered little from grazing by domestic livestock. Indicators of overuse (e.g., close-cropped vegetation, reduction of grass cover, dust wallows, dung, etc.) were absent from all but the extreme NE corner of the area adjacent to the stock pond. In the open juniper woodland immediately east of the RNA many shrubs of *A. arbuscula* appear to be closely cropped and there appears to be a lower cover of grasses and some herbs than in the same association in the RNA. Because of the nearly continuous 10-20 ft. high scarp along the eastern RNA boundary, a large proportion of the cattle in the Rimrock Valley area are dissuaded from entering the RNA. The western side of the RNA is protected to some degree by a drift fence which runs along the dirt road ca ½ mile west of the RNA boundary. All cattle I observed in the vicinity of the RNA were concentrated in the *Juncus*-dominated meadow in upper Rimrock Valley (ca. 35 head). I saw no sign of horses anywhere in the RNA.

At the base of the rimrock just inside the RNA boundary cattle

had been regularly resting in the shade provided by the dense growth of Juniperus. In a small part of this area duff and understory vegetation had been completely cleared away leaving a dust wallow. Fresh dung and flies were numerous at this spot.

The only other points visibly affected by livestock within the boundaries are the fire-break trails at the 1959 burn. None of these trails appeared heavily used in 1983, but some hoof prints and old dung probably from the past spring were present. The reason these trails are used by cattle involves their origin at a natural low, passable gap in the rimrock ca. 200 m east of the RNA boundary.

It is my belief that by fencing the short (ca. 100 m) gap where the bulldozed trail traverses the fault scarp, and by fencing in the small acreage (less than 1 acre) at the east side of the rim-rock on the NE corner of the RNA the major grazing conflicts in the RNA could be solved. The labor and the cost of this project would be minimal.

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APPENDIX I

Vascular Plants from the Devil's Garden RNA

This list of ca. 104 taxa includes all the species tentatively identified during my visit to the area in mid-August 1983. A few additional species are listed that are likely to be found in the RNA earlier in the growing season. The symbols following species names refer to local vegetetion types where they occur; e.g.

oj = open juniper woodland

uaa = upland Artemisia arbuscula shrub-steppe

rr = rimrock association

baa = basin Artemisia arbuscula-Chrysothamnus viscidiflorus subsp. pumilis association

soj = successional open juniper woodland on 1959 burn

Taxonomy generally follows Munz "A California Flora". U.C. Press, Berkeley.

Pinaceae
- Pinus ponderosa. 1 sapling seen in rr

Cupressaceae
- Juniperus occidentalis subsp. occidentalis. the sole dominant of oj, also rr

Violaceae
- Viola beckwithii. likely in oj and uaa

Cruciferae
- Thelypodium flexuosum. oj. uaa, fairly common.
- Idahoa scapigera. oj, uaa
- Draba verna. oj, uaa
- Arabis holboellii var retrofracta. oj, uaa
- A. sparsiflora. oj, uaa

Caryophyllaceae
- Arenaria douglasii. oj
- A. aculeata. oj, uaa
- A. congesta. uaa, occasional in oj
- A. nuttallii subsp fragilis. soj

Polygonaceae

Eriogonum douglasii. oj, uaa, baa
E. umbellatum var. modocense. oj. uaa endemic to Modoc Plateau
Polygonum douglasii. baa
P. esotericum. oj, uaa, baa endemic to Modoc Plateau

Primulaceae
Dodecatheon conjugens. oj

Polemoniaceae
Polemonium micranthum. oj
Phlox douglasii subsp. rigida. uaa, oj
Gilia lepetela. oj, uaa
G. tenerrima (?). oj if this species, a range extension from Ore.
Navarretia minima. uaa, baa
N. breweri. possible uaa, baa

Hydrophyllaceae
Hydrophyllum capitatum var.alpinum. possible oj,uaa
Phacelia imbricata. rr, soj

Boraginaceae
Hackelia cusickii. oj
Plagiobothrys cusickii. oj, uaa

Scrophulariaceae
Verbascum thapsus. soj, rr
Penstemon cinereus. possible oj
P. deustus subsp. heterander. rr
P. speciosus. uaa, oj
P. laetus subsp. roezlii. oj, uaa
Scrophularia lanceolata. rr rare in California
Collinsia parviflora. oj
Cordylanthus ramosus. oj, uaa

Saxifragaceae
Saxifraga fragosa. oj
Lithophragma rupicola. oj endemic to Modoc region.
Ribes cereum. rr
R. velutinum. rr, oj

Rosaceae
Geum ciliatum. soj, rr
Purshia tridentata. soj, rr, rare in oj
Cercocarpus ledifolius. rr
Prunus virginiana var. melanocarpa. rr
Amelanchier pallida. rr, soj

Leguminosae
Trifolium macrocephalum. possible oj, uaa
T. gymnocarpon var. plummerae. oj, uaa, baa

Onagraceae
Epilobium paniculatum. oj, uaa, baa
Gayophytum racemosum. uaa, baa
G. humile. uaa baa

Loranthaceae
    Phoradendron juniperinum var ligatum. oj, rr

Umbelliferae
    Perideridia bolanderi. uaa, baa
    Lomatium leptocarpum. uaa, baa
    L. triternatum. uaa, oj
    L. nudicaule. oj, uaa
    L.

Capriofoliaceae
    Sambucus caerulea. rr

Valerianaceae
    Plectritis macrocera var grayii. oj

Compositae
    Wyethia mollis. rr
    Balsamorhiza hookeri. oj, uaa, baa
    Madia citriodora. soj
    Hemizonia lobbii. uaa, soj, oj introduced from C. California ?
    Eriophyllum lanatum var. achillaeoides. oj, uaa
    Haplopappus stenophyllus. oj, uaa
    Chrysothamnus viscidiflorus. rr, soj
    C. v. subsp. pumilus. baa
    C. nauseosus subsp. albicaulis. rr, soj
    Erigeron chrysopidis subsp. austinae. oj
    E. bloomeri. possible oj, uaa
    E. linearis. oj, uaa
    E. elegantulus. oj, uaa
    Achillea lanulosa. rr, soj
    Artemisia tridentata. rr, soj
    A. arbuscula. oj, uaa, baa, soj, rr
    Senecio integerrimus. oj, soj
    Antennaria dimorpha. oj, uaa
    A. luzuloides. uaa, oj
    Cirsium utahense. rr, soj
    Microseris lacinata. oj, uaa
    Agoseris glauca var. lacinata. possible in oj
    Crepis modocensis. oj, uaa
    C. acuminata. soj

Liliaceae
    Leucocrinum montanum. possible in oj, uaa
    Zigadenus paniculatus. oj, uaa
    Fritillaria pudica. oj
    Lilium washingtonianum. possible in oj, uaa
    Calochortus macrocarpus. oj, rr

Amaryllidaceae
    Allium acuminatum. oj uaa

Cyperaceae
    Carex douglasii. rr

Graminae
    Bromus brizaeformis. rr, oj, uaa,

Bromus japonicus. rr, oj, uaa
B. tectorum. rr, oj, uaa, soj
Festuca idahoensis. oj uaa
Poa fibrata. possible in uaa tentitively identified in oj
P. juncifolia (brachyglossa). oj, uaa, baa
P. ampla. possible in oj
P. sandbergii. likely in oj, uaa
Agropyron spicatum. rr, oj
Elymus triticoides. rr
Sitanion hystrix. rr, oj. soj, baa
Koelaria cristata. oj. uaa,
Danthonia unispicata. oj
Stipa thurberiana. oj, uaa
S. occidentalis. oj
S. columbiana (?) or S. williamsii(?). common oj, uaa

APPENDIX II

VERTEBRATES KNOWN FROM OR LIKELY TO BE FOUND AT DEVIL'S GARDEN RNA

These lists include all amphibians, reptiles, and mamals expected to occur in the RNA as well as those species actually seen by me in August 1983. The list of birds only includes those species identified by me (with one exception).

Amphibians:

Great Basin Spadefoot Toad; possible in Rimrock Valley.

Western Toad; seen in Rimrock Valley.

Pacific Treefrog; common in stock pond and NE portion of RNA following rain.

Reptiles:

Leopard Lizard; possible in open juniper and Artemisia habitats.

Collared Lizard; possible in rimrock association.

Western Fence Lizard; possible in rimrock association.

Sagebrush Lizard; common in open juniper woodland.

Side-blotched Lizard; possible juniper woodland inhabitant.

Short-horned Lizard; possible in open juniper and Artemisia.

Western Skink; young individual seen in juniper woodland.

Western Whiptail; Possible in juniper woodland and Artemisia.

Striped Whipsnake; possible in juniper woodland and Artemisia.

Racer; possible in open habitats

Gopher Snake; possible throughout.

Common Garter Snake; possible in Rimrock Valley.

Western Rattlesnake; possible in all habitats.

Birds:

Double-crested Cormorant; a pair flying over RNA toward South Mtn. Reservoir.

Great Blue Heron; one seen flying over Rimrock Valley.

Canada Goose (<u>Branta canadensis canadensis</u>) breeds on reservoirs in vicinity of RNA, seen flying overhead.

Mallard; seen Flying over RNA

Pintail; seen over Rimrock Valley.

Turkey Vulture; seen over RNA.

Red-tailed Hawk; seen over RNA.

American Kestrel; seen in RNA perched on junipers.

Caspian Tern; seen flying over Rimrock Valley.

Black Tern; seen flying over RNA.

Mourning Dove; seen in Rimrock Valley.

Common Nighthawk; heard at dusk over Rimrock Valley.

Hairy Woodpecker; seen in rimrock association.

Gray Flycatcher; seen in rimrock association.

Horned Lark; seen at stock pond adjacent to RNA

Stellar's Jay; present in dense junipers in rimrock association.

Scrub Jay; common throughout juniper zone especially rimrock.

Black-billed Magpie; a pair seen flying over the RNA.

Mountain Chickadee; one of the most common birds of juniper zone.

Plain Titmouse; heard in open juniper woodland.

Red-breasted Nuthatch; fairly common in junipers.

Brown Creeper; seen in rimrock and open juniper associations.

Bewick's Wren; seen in dense vegetation in rimrock.

Rock Wren; seen in open vegetation and rocks in rimrock.

American Robin; commonly feeding on <u>Prunus virginiana</u>, rimrock.

Western Bluebird; several seen in Rimrock Valley.

Mountain Bluebird; female or juvenile seen in open juniper zone.

Bohemian Waxwing; nomadic visitor to Modoc Plateau in winter, feeds on juniper berries, probably occasional in RNA.

Yellow-rumped (Audubon's) Warbler; several seen in junipers.

Brewer's Blackbird; seen in Rimrock Valley.

Rufous-sided Towhee; seen in rimrock association.

Vesper Sparrow; several seen in A. tridentata bushes adjacent to NE boundary of RNA.

Dark-eyed Junco; seen in rimrock and open juniper areas.

Mammals:

Trowbridge Shrew; possible in rimrock.

Merriam Shrew; possible in thicker bunchgrass.

Broad-handed Mole; possible in looser soil.

Little Brown Myotis; possible in all habitats.

Fringed Myotis; possible in all habitats.

Hairy-winged Myotis; possible.

Long-eared Myotis; possible.

Yuma Myotis; possible.

Silvery-haired Bat; possible

Hoary Bat ; possible.

Big Brown Bat; possible.

Pallid Bat; possible.

Brazilian Free-tailed Bat; possible.

Black-tailed Hare; seen in Rimrock Valley

White-tailed Hare; likely in open habitats

Pigmy Rabbit; possible in dense brush.

Nuttall Cottontail; seen in rimrock

Beechey Ground Squirrel; possible.

Golden-mantled Ground Squirrel; uncommon in rimrock and open juniper woodland.

Least Chipmunk; possible in Artemisia and open juniper areas.

Yellow Pine Chipmunk; fairly common in rimrock and juniper zones.

Douglas Squirrel (chickaree); heard in area, rimrock and open juniper. Surprising resident because no pines.

Northern Pocket Gopher; mounds seen in rimrock area.

Great Basin Pocket Mouse; possible

Western Harvest Mouse; possible.

Canyon Mouse; possible.

Brush Mouse; possible.

Pinyon Mouse; possible.

Deer Mouse; possible.

Northern Grasshopper Mouse; possible.

Bushy-tailed Woodrat; stick houses very numerous in rimrock, less so in open juniper zone, builds in trees and in rocky areas, guano deposits on rimrock.

Porcupine; bark stripped off junipers in rimrock by this species.

Coyote; heard in late afternoon following thunder shower.

Long-tailed Weasel; possible.

Badger; possible.

Striped Skunk; possible

Bobcat; tracks on road in Rimrock Valley.

Mule Deer; possible

Pronghorn; possible

Horse; wild horses common in early part of this century, some apparently still in the vicinity.